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Stevens
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Attorney Docket SEL 123

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re Application of)
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Akiharu MIYANAGA et al.)
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Serial No.: 09/241,695)
)
Filed: February 2, 1999)
)
For: Semiconductor Device And Process)
For Producing The Same)
)
Art Unit: 2811)
)
Examiner: S. Hu)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: the Assistant Commissioner for Patents, Washington, D.C. 20231 on May 12, 2000

Christine Muilenburg

Signature 5-12-2000 Date

Assistant Commissioner for Patents
Washington, D.C. 20231

May 12, 2000

RESPONSE B (AFTER FINAL)

Sir:

The following is being submitted in response to the Final Rejection dated February 14, 2000.

REMARKS

In the Final Rejection, the Examiner is maintaining the rejection of Claims 1-4, 14-15, 18, 21, 24, 27 and 28 under 35 U.S.C. 103(a) as being unpatentable over Chang et al. This rejection is respectfully traversed.

The present invention, as recited in independent Claim 1, is directed to a semiconductor device including a channel forming region and an impurity region which is formed under the channel forming region, wherein an impurity with an opposite conductive type to a source region and a drain region is included in the channel forming region at a concentration of 1/100 to 1/10

compared with the impurity region, and wherein the impurity is introduced into the impurity region in a direction of the <110> axis with respect to a single semiconductor substrate. This is different than what is disclosed and suggested by Chang.

First, as the Examiner agrees, Chang does not explicitly disclose that the concentration of the impurity in the channel forming region is from 1/100 to 1/10 of that in the impurity region (as specifically recited in the claims of the present application). The Examiner, however, argues that ". . . the ratio of impurity concentrations in these two regions in Chang's MOSFET is in a range substantially covering 1/100 to 1/10, given the disclosed doping dosage and the doping pocket broaden range (vertical width) and the typical impurity concentration in a non-heavily doped channel forming region." Furthermore, the Examiner also asserts that, "the impurity concentration of the impurity doped region is a well recognized parameter of importance subject to routine experimentation and optimization."

The Examiner cites Chang, col. 3, lns. 49-61 in support of his rejection. In this section, Chang teaches that N-type impurity is implanted at a dose in a range from 3×10^{12} to 4×10^{12} atoms/cm^2, and preferably, 4×10^{12} atoms/cm^2 (col. 3, lines 49-54). Chang further states that the vertical doping location y-peak ranges from about 50 to 60 nm. The vertical broaden width of implantation y-char is at a width about 40 nm (col. 3, lines 58-61). The Examiner then alleges that the impurity concentration is roughly estimated to be about 1×10^{18} atoms/cm^3.

Applicant, however, does not agree that the Examiner's estimated value of the impurity concentration is the exact one in Chang's ion-implanted region 18. In Chang, the sidewall spacers 15 are formed on the edges of polysilicon gate electrode 19 (col. 3, lines 29-30). Therefore, when the ion implantation is carried out, the sidewall spacers are located in the path of some of the impurity ions and block those ions from being implanted. Thus, it is not possible for all of the ions to be implanted into the region 18.

Further, in Chang there are P⁻type LDD (lightly doped drain) regions 14, which include p-type impurity that are opposite to the n-type impurity included in the region 18. The regions 14 are also formed in the path of possible implantation (col. 3, lines 21-27). Hence, the P⁻type LDD regions also obstruct some of the impurity ions from entering into the region 18. The Examiner's estimate of impurity concentration does not appear to take these factors into consideration.

Finally, the Examiner asserts that the non-heavily doped channel forming region normally has an impurity at a concentration in a range of 1×10^{16} to 1×10^{17} atoms/cm^2. However, there is no evidence of the impurity in the channel region at such a concentration, and the reference fails to recite such a concentration.

As a result, it is respectfully submitted that the Final Rejection is incorrect in alleging that Chang discloses the ratio of the impurity concentrations between the impurity region and channel forming region of the claimed invention, based on the values estimated from Chang's dosage and depth of ion implantation. Accordingly, this is a limitation in the claims of the present application that is not disclosed or suggested by Chang.

The Examiner also concedes that there is no disclosure in Chang of the impurity being introduced from a direction of the <100> axis with respect to the single semiconductor substrate (as specifically recited in the claims of the present application). The Examiner, however, argues that the impurity doping direction in Chang can be presumed inherently along the <110> direction, because a conventional MOSFET is formed with the wafer surface being parallel to the (100) crystal plane and Chang shows in Fig. 3(c) that the implantation direction is 45 degrees to the vertical.

However, Chang merely discloses the large-angle-tilt (LATI) implant to form an ion-implanted region 18 (col. 3, lines 49-51).

In contrast, the present application explains the advantage of introducing the impurity from a direction at the <100> axis. In particularly, the specification of the present application explains

that silicon has the smallest atom density on the {110} face, and that by adding an impurity ion from the <110> axis, the impurity ion can be added to a deeper position with little damage (page 4, lines 11-13). Chang not only fails to describe the exact implanting direction, but also fails to provide any mention or suggestion of the advantage of the introduction along <110> axis. Accordingly, Applicant submits that there is no disclosure or suggestion, either explicitly or inherently, of this feature of the claims of the present application.

Accordingly, it is respectfully submitted that the claims of the present application are patentably distinguishable over the cited reference and should now be allowed.

Favorable reconsideration is earnestly solicited.

Respectfully submitted,

Date: May 12, 2000

Mark J. Murphy
Registration No. 34,225

COOK, ALEX, McFARRON, MANZO,
CUMMINGS & MEHLER, LTD.
200 West Adams Street
Suite 2850
Chicago, Illinois 60606
(312) 236-8500